Defense Stability and Ecosystem Sustainability in the Strait of Malacca: Maritime Security Challenges from an International Relations Perspective

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Abstract. This study examines the challenges of defense stability and ecosystem sustainability in the Strait of Malacca, one of the most strategic shipping lanes in the world. The strait plays a crucial role in global trade and geopolitics; however, the high volume of maritime traffic has led to issues such as maritime security threats, including piracy, smuggling, and geopolitical tensions, as well as environmental threats like marine pollution and ecosystem degradation. Cooperation between coastal countries such as Indonesia, Malaysia, and Singapore through the Cooperative Mechanism has successfully reduced security threats and environmental impacts, though significant challenges remain. The research employs a qualitative approach through literature reviews and document analysis. It focuses on the interaction between defense stability and ecosystem sustainability from an international relations perspective, including the role of security actors and environmental diplomacy. The findings reveal that defense stability in the Strait of Malacca is closely linked to regional cooperation and international power support. The use of advanced technologies such as satellite monitoring has enhanced maritime security, yet stronger environmental protection policies are still needed. In conclusion, the stability of the Strait of Malacca requires effective mitigation through cross-border cooperation, international policies, and enhanced monitoring technologies to safeguard this vital route for the global economy and the environment.

1 Introduction

The Strait of Malacca, one of the busiest and most strategic maritime routes in the world, plays a vital role in global trade and geopolitics. More than 60,000 ships pass through these waters annually, connecting Western and Eastern economies. However, this heavy maritime traffic poses significant challenges in terms of both security and environmental sustainability [1]. Pollution from ships, such as oil spills and waste disposal, poses a serious threat to marine biodiversity, while overfishing and habitat destruction exacerbate

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ecological degradation in the region [2]. The complex interaction between defense stability and ecosystem sustainability in the Strait of Malacca has drawn the attention of international stakeholders, prompting cooperative efforts between Indonesia, Malaysia, and Singapore to manage maritime security and reduce environmental impacts [3].

Historically, these three coastal nations have cooperated since the 1970s through various agreements, with the Cooperative Mechanism being one of the most notable initiatives aimed at reducing marine pollution [3, 4]. Despite these efforts, the region remains vulnerable to maritime security threats such as piracy, smuggling, and potential geopolitical tensions, all of which can adversely affect both the local environment and the global economy. The "Malacca Paradox," where increased maritime activity spurs economic growth while simultaneously heightening the risk of disruption, highlights the delicate balance that must be maintained in this crucial region [5].

This study aims to explore the challenges of maintaining defense stability and ecosystem sustainability in the Strait of Malacca from an international relations perspective. By analyzing the environmental and security issues facing the strait, this study seeks to provide insights into how regional cooperation and international diplomacy can effectively address these challenges. Additionally, the role of security actors and their perceived responsibilities in protecting the environment and ensuring maritime security will be examined [6]. Understanding the interconnection between these two critical issues is essential for formulating policies that ensure long-term stability and environmental protection in the Strait of Malacca region.

2 Method

A qualitative research design is the appropriate approach for this study. Through literature review and document analysis, it is expected to provide clarity regarding defense stability, environmental sustainability, and maritime security in the Strait of Malacca. Research utilizing literature reviews and document analysis serves an important role. Aspects such as historical context, new reference questions, additional data, tracking changes and developments, and verifying findings or evidence from other sources can be summarized through this approach [7].

The data source used is secondary data, which serves as the primary data source for this study. Secondary data is information collected and published by other parties for purposes other than the current research. Using this data is more efficient as it saves time and cost, allowing researchers to utilize existing information without the need for new data collection. Secondary data has a broader geographical and historical scope and can be used for reanalysis or to answer different research questions. However, researchers have no control over the data collection process, which may affect its quality or relevance [8].

The data analysis techniques used include thematic analysis and content analysis, which aim to identify the main themes and patterns related to the research topic. Thematic and content analysis are two qualitative methods commonly used to understand textual data. While they have different approaches, they complement each other in interpreting the meaning of the analyzed data [9]. To enhance accuracy, specific criteria were applied in selecting relevant documents and studies. The sources included in the analysis were required to meet the following conditions:

a. Relevance to the main theme: The sources must directly address issues related to defense stability, environmental sustainability, or maritime security.
b. Contribution to knowledge: Only documents that provide substantial insights or background information regarding the context of the Malacca Strait were selected.
c. Verifiability: Documents with credible and verifiable references were prioritized.

d. Timeliness: Preference was given to studies and reports published within the last five to ten years to ensure data accuracy and relevance to current conditions. Older documents beyond this timeframe were considered as supplementary resources to strengthen the research framework and analysis.
e. Source credibility: Publications from reputable journals, particularly those indexed in the Scopus database, were prioritized. Other databases were also considered to maintain the quality of information.

Thematic and content analyses were employed as complementary techniques to uncover patterns and key insights within the data. The processes for each technique are detailed in Table 1 below:

Table 1. Process of uncovering thematic and content patterns.

Analysis Pattern	Steps	Description
Thematic	1	Reading all selected documents to understand their overall content and context.
	2	Coding relevant text segments related to defense, sustainability, and security issues in the Malacca Strait.
	3	Grouping similar codes to form initial themes, focusing on recurring ideas or issues.
	4	Reviewing and refining these themes to align with the research objectives and accurately represent the main topics.
	5	Finalizing themes that align with the research questions and provide a coherent framework for discussion.
Content	1	Identifying keywords and phrases frequently associated with the main topics, such as “maritime security,” “environmental sustainability,” or “defense stability.”
	2	Mapping the frequency and distribution of these keywords across various documents to identify patterns.
	3	Interpreting these patterns to understand the emphasis on each theme and the relationships between them.
	4	Drawing connections between findings from content analysis and thematic analysis to construct a more comprehensive interpretation of the data.

By rigorously implementing these steps in source selection and analysis, this study aims to enhance transparency in the research process and ensure that the findings are robust, well-supported, and relevant to the established objectives.

3 Results and Discussion

3.1 Defense Stability in the Straits of Malacca

The Strait of Malacca, as a strategic shipping route connecting the Indian and Pacific Oceans, is a vital route in global trade. The economic stability and security of coastal countries like Indonesia, Malaysia, and Singapore depend heavily on the smooth flow of trade. However, its strategic location also exposes the Strait of Malacca to maritime

security threats, including piracy, smuggling, and territorial conflicts, as this route connects oil-producing countries in the Middle East with industrial nations in East Asia [10].

To address these challenges, the countries in the region have collaborated on various maritime security efforts. The Cooperative Mechanism between Indonesia, Malaysia, and Singapore is one successful example of regional cooperation aimed at enhancing security and reducing threats in the Strait of Malacca [4]. This cooperation involves not only joint maritime patrols but also the implementation of advanced technologies such as satellite monitoring to detect potential threats and environmental pollution that could harm marine ecosystems [11]. Global efforts also involve international organizations and major powers, where countries that use this shipping route, such as Japan and the United States, provide support to strengthen regional stability through maritime diplomacy and investment in maritime defense capacity building.

When discussing defense stability in the Strait of Malacca, it is important to relate it to the Security Complexity Theory. This theory emphasizes that the security of one country is influenced by the security conditions of neighboring countries [12]. Maritime threats such as piracy, smuggling, and territorial conflicts create interlinked security dynamics among coastal nations, namely Indonesia, Malaysia, and Singapore, as well as international powers with vested interests in the region.

When one country enhances its defense capacity through initiatives such as the Cooperative Mechanism, the stability of that country not only impacts itself but also affects neighboring countries and external actors. Strengthening maritime security through joint patrols and monitoring technology can enhance the region's resilience, but it may also trigger responses from major powers such as the United States and Japan, which have a stake in maintaining the security of trade routes.

The situation in the Strait of Malacca reflects the complexity of interactions between various actors and interconnected threats. Piracy, drug/human trafficking can influence the security policy decisions of neighboring countries to collaborate more closely. When examined more closely, the threats present in the region necessitate a concept of defense cooperation among the littoral states, such as Indonesia, Malaysia, and Singapore [13]. Defense cooperation is a form of collaboration focused on national interests, particularly those related to sovereignty, security protection, regional stability, and the improvement of societal welfare [14]. The reasons underlying the necessity and importance of defense cooperation are detailed in Table 2 as follows: [15]

Table 2. The reasons for the importance of defense cooperation.

No	Reasons for the Establishment of Defense Cooperation	Description
1	Threat assessment	Each state possesses its own perspective on threats, whether traditional or non-traditional, stemming from both state and non-state actors. Based on an analysis of these threats, states design appropriate defense strategies to prevent and address them effectively.
2	Country situation	Changes in a nation's strategic environment also serve as a critical factor in the formation of defense cooperation. The evolving dynamics of the strategic environment influence the regional power configuration, which ultimately affects patterns of inter-state relations. Thus, the strategic conditions faced by a state form the basis for determining the nature of defense cooperation.
3	Development of weapons technology	A nation's military strength can, in part, be measured by its arsenal systems. Variations in weapons technology capabilities among states provide a compelling rationale for establishing defense cooperation in

No	Reasons for the Establishment of Defense Cooperation	Description
		the area of primary weapons systems. Such cooperation aims to support the procurement of defense systems, military technology modernization, and technology transfer, thereby promoting research and development to achieve self-reliance in national defense.

Therefore, understanding defense stability in the Strait of Malacca requires a broader context, where inter-country relations and interactions with international powers are critical in shaping maritime security. Maritime collaboration and diplomacy become crucial in addressing shared threats and ensuring the continued functioning of the vital Strait of Malacca for the global economy, while preserving environmental sustainability.

3.2 Maritime Security Challenges in the Straits of Malacca

Maritime security in the Strait of Malacca faces significant challenges in balancing increased defense capacity with environmental preservation. As one of the busiest shipping lanes in the world, over 30% of global oil shipments pass through this strait [5]. Coastal countries like Indonesia, Malaysia, and Singapore, along with international powers, must work together to ensure the shipping route remains safe from threats such as piracy, smuggling (of drugs/humans), and terrorism, without harming the sensitive marine ecosystem.

Maritime activities also contribute to marine pollution, including oil spills and overfishing, which threaten the sustainability of resources and biodiversity [1]. Therefore, coastal countries need to adopt a holistic approach that considers both security and environmental sustainability [3]. Additionally, the policies implemented must be consistent with international standards and agreements, such as UNCLOS and other environmental protection treaties [2]. Multilateral cooperation, such as the Cooperative Mechanism between Indonesia, Malaysia, and Singapore, is essential to addressing these challenges, including joint maritime patrols and the development of monitoring technologies to detect threats [11]. Support from major powers such as the United States and Japan can also strengthen security efforts in the Strait of Malacca.

In addressing various challenges, particularly in the realms of security and the environment, and in maintaining a balance, the littoral states can implement mechanisms previously established. From an international relations perspective, these mechanisms are encapsulated in the Maritime Security Theory. In the context of the Malacca Strait, this theory emphasizes the importance of multilateral cooperation mechanisms in safeguarding a region that is crucial for global trade, among other contexts [16]. The security mechanisms that can be implemented and developed by the littoral states in the Malacca Strait are explained in Table 3 as follows:

Table 3. Cooperation mechanisms in maintaining security and environmental stability.

No	Cooperation Mechanisms	Description
1	Malacca Straits Sea Patrol (MSSP)	The Malacca Straits Sea Patrol (MSSP) is part of the Malacca Sea Patrol (MSP) framework, focusing on maritime security in the Malacca Strait. This patrol is the result of collaboration between Indonesia, Malaysia, and Singapore, initiated in July 2004 to reduce piracy and enhance surveillance in the strait. MSSP relies on command centers in each of the countries: Indonesia operates centers in Batam and Belawan, Malaysia in Lumut, and Singapore in Changi. In its implementation, MSSP adopts a coordinated patrol concept, which differs from joint patrols. Coordinated patrols are conducted in each country's waters without entering the waters of other nations, with coordination of reports during operations. Meanwhile, joint patrols involve vessels from multiple countries in the same area. The MSSP mechanism involves naval forces patrolling their respective waters and sharing information through their respective naval operation centers [13].
2	"Eyes-in-the-Sky" Combined Maritime Air Patrols (EiS)	The "Eyes-in-the-Sky" (EiS) program is a joint aerial patrol aimed at monitoring the security of the Malacca Strait's waters from the air. The patrol is conducted using Maritime Patrol Aircraft (MPA) deployed by Indonesia, Singapore, Malaysia, and Thailand. Each mission involves a combined team consisting of personnel from the host nation and officers from other participating countries. EiS is carried out with the provision that each country conducts aerial patrols twice a week. Each flight carries a joint patrol team to carry out missions in the international and national airspace along the Malacca Strait. Monitoring can extend up to three nautical miles from the sovereign waters of the participating countries. The operation centers of EiS are located in each country to manage flight schedules and mission coordination [17].
3	MSP Intelligence Exchange Group (IEG)	The MSP Intelligence Exchange Group (IEG) supports maritime and aerial patrols through the management and sharing of information using the Malacca Straits Patrol Information System (MSP-IS). This system is managed by the Fusion Centre Information (IFC) and includes the Open and Analysed Shipping Information System (OASIS) and the Sense-Making Analysis and Research Tool (SMART), which enables the rapid delivery of monitoring results by personnel in the Malacca Strait. The strategic position of the Malacca Strait creates various national interests for Indonesia, Malaysia, and Singapore, while also posing potential threats that require defense collaboration. The MSP mechanism is a form of defense diplomacy, encompassing multilateral contacts between military officials and joint military exercises. This diplomacy plays a role in addressing differing perspectives, particularly between Singapore, which supports the presence of user states as security providers, and Indonesia and Malaysia, which reject such external involvement based on the UNCLOS. By fostering mutual trust between countries, the potential for conflict in cooperation can be minimized [18]. Military personnel interaction during coordinated patrols also supports the development of defense capabilities, particularly within the naval and air forces. Through knowledge sharing and field training, the military capabilities of participating countries can be significantly enhanced, thereby strengthening the effectiveness of collaboration in safeguarding the Malacca Strait.

Regarding environmental security, coastal countries in the Strait of Malacca, such as Indonesia, Malaysia, and Singapore, should implement environmental diplomacy. According to [19], environmental diplomacy is an evolving concept in which nations work together to address cross-border environmental challenges. This concept illustrates how countries can combine diplomatic efforts to address environmental sustainability issues, including protecting the maritime ecosystem in the Strait of Malacca. In this context, environmental diplomacy is reflected in various international agreements focused on marine resource management and pollution prevention in the region.

3.3 Ecosystem Sustainability

Maritime activities in the Strait of Malacca present not only security challenges but also serious environmental impacts. Pollution from passing ships, especially oil spills and ship waste, as well as disturbances from military activities such as exercises and patrols, have caused significant damage to marine ecosystems [1]. Coastal ecosystems and coral reefs are particularly vulnerable to this pollution, leading to a decline in marine biodiversity. Additionally, overfishing in the waters of the Strait of Malacca exacerbates the problem, with many fish species and marine life at risk of extinction [3]. These conditions worsen environmental degradation in these waters, disrupting the balance of marine ecosystems and harming marine-based economies, such as fisheries and tourism.

Coastal countries in the Strait of Malacca, such as Indonesia, Malaysia, and Singapore, have implemented various mitigation efforts to address these issues. One important step is the enforcement of maritime pollution control policies through the Cooperative Mechanism, which has been in place since the 1970s [4]. his cooperation includes initiatives such as joint patrols to prevent oil spills and illegal fishing, as well as the implementation of modern monitoring technologies, such as remote sensing and satellite systems, to detect pollution in the waters [6, 20].

Furthermore, these countries are also working to tighten regulations related to fishing through quota policies and marine protection zones to prevent overexploitation of marine resources [21]. However, the main challenges lie in the effective implementation and enforcement of environmental policies, as well as in the coordination among countries to ensure consistent actions against environmental violations [22]. With increasing maritime and military activities in the Strait of Malacca, the significant environmental impacts continue to grow. Marine pollution, ecosystem degradation, and overfishing remain major threats to the sustainability of natural resources in this region. Mitigation efforts involving international policies, monitoring technologies, and stricter law enforcement must be continually enhanced to maintain the ecosystem balance and preserve marine resources vital to the regional economy.

One of the technologies successfully implemented for mitigating such impacts is the use of the Automatic Identification System (AIS) and satellite-based monitoring, such as the Sentinel-2 technology from the Copernicus program. AIS enables real-time monitoring of vessel traffic, while Sentinel-2 provides high-frequency, multi-spectral data, aiding in the identification of illegal activities such as overfishing and waste dumping in waters, particularly in the Malacca Strait. This technology also supports more efficient vessel traffic management. Additionally, the deployment of maritime drones and unmanned surface vessels (USVs) has begun to facilitate patrols in areas that are difficult to access [23, 24]

These technologies, including automatic detection algorithms for comparing AIS data with radar imagery, allow for the identification of vessels not transmitting AIS signals, thereby strengthening law enforcement efforts. The implementation of such technologies has proven to enhance surveillance efficiency and expedite responses to violations. This

advanced technological integration not only directs law enforcement more effectively in the Malacca Strait but also positively impacts ecosystem sustainability and ensures the continuity of marine resources vital to the regional economy. Consequently, integrating these technologies with international policies and cross-border cooperation must be continuously enhanced to optimize maritime environmental management [23, 24].

Additionally, from an international relations perspective, these cross-border efforts align with Neoliberal Institutionalism theory. This theory emphasizes the importance of international collaboration through institutions and rules to address global challenges, including security and environmental issues [25]. In the context of the Strait of Malacca, coastal countries and major powers such as the United States, China, and Japan collaborate through institutional frameworks like the International Maritime Organization (IMO) and regional agreements. This cooperation is essential for ensuring the security of shipping routes while protecting the marine environment through the implementation of mutually agreed international regulations.

4 Conclusion

The Strait of Malacca, as one of the most strategic and busiest shipping routes in the world, faces significant challenges in terms of defense stability and ecosystem sustainability. The global trade passing through this strait has a major impact on both security and the environment. Maritime threats such as piracy, smuggling (of drugs and humans), territorial conflicts, and military activities cause damage to vital marine ecosystems, particularly coral reefs and coastal ecosystems.

This study found that regional cooperation among coastal countries, such as Indonesia, Malaysia, and Singapore, through the Cooperative Mechanism has successfully helped reduce security threats and environmental pollution. Joint patrols and the use of advanced technology, such as satellite monitoring, are key to maintaining the region's stability. However, challenges remain, particularly regarding the consistent implementation and enforcement of environmental policies, as well as stronger coordination among coastal countries.

From the perspective of Security Complexity Theory, stability in the Strait of Malacca depends on the interaction between coastal countries and international powers. Maritime threats in this region not only affect one country but also have a domino effect on neighboring countries and the global economy as a whole. Cross-border cooperation, regulated by international institutions such as the International Maritime Organization (IMO), and the implementation of comprehensive international agreements are key to addressing the environmental and security issues in the Strait of Malacca.

Therefore, to safeguard ecosystem sustainability and security stability in the Malacca Strait, more effective mitigation efforts are needed through international policy frameworks, advancements in monitoring technology, and stricter law enforcement. Cooperation among littoral states and major powers should be strengthened, particularly in line with commitments outlined by the International Maritime Organization (IMO), ensuring that this vital shipping lane remains secure and environmentally friendly for future generations.

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